Appendix B Stormwater Management Design

(Revised 10/25/04)

The following module establishes guidelines, which compliment the standards set forth in the Municipal Code of the City of Lynchburg. The methods and procedures presented in this section are intended to establish minimal guidelines for stormwater management.

Alternative design methods may be considered by the Engineer/Designer on a case-by-case basis; however, there should not be extensive variations from the criteria and procedures within this division without the expressed approval of the City Engineer.

1.1 PLAN APPROVING AUTHORITY

The City Engineer shall be responsible for interpretation and implementation of the stormwater management and design criteria for the public projects and new subdivisions within the City of Lynchburg. The City Environmental Planner shall be responsible for private development projects within the City of Lynchburg. Approval from other applicable agencies may be required.

1.2 CITY OF LYNCHBURG STORMWATER MANAGEMENT CODE

It is the policy of the City of Lynchburg that all developed land within the City Limits has adequate stormwater facilities and controls to ensure the protection and safety of life and property. The City may accept stormwater management systems for maintenance if the system provides drainage for streets that have been accepted for maintenance by the City and have been designed and constructed in accordance with the provisions of the Stormwater Management and Erosion & Sediment Control Codes of the City Code (also located on the City of Lynchburg website) and the City's Engineering Division.

2.0 PLAN SUBMITTALS

The purpose of this section is to establish the minimal plan submittal requirements for plan review and approval of Stormwater facilities.

2.1 SUBMITTAL REQUIREMENTS

Seven (7) complete sets of site plan drawings and two (2) complete sets of sitework calculations shall be submitted to the City of Lynchburg Engineering Division of Public Works, Attn: City Engineer for review and approval and shall include:

2.1.1 Certification Requirements

The following certifications shall appear on the first Stormwater Management sheet in the plan set.

2.1.1.1 Designer's Certification

"I hereby certify that, to the best of my ability, this plan has been prepared in accordance with the latest City of Lynchburg Manual of Specifications and Standard Details and City Code."

Signature:_____
Printed Name and Title:_____
Date:_____ Registration Number: _____

2.1.1.2 Owner's/Developer's Certification

"I/We hereby certify that all site construction, drainage and grading will be done pursuant to this plan and that the applicable Stormwater Management conditions and requirements of the City of Lynchburg, the Commonwealth of Virginia and the Federal Government and its agencies are hereby made part of this plan."

Signature:_____
Printed Name:_____
Title:_____ Date:_____

2.1.2 Checklist of Stormwater Standards

The following checklist shall be submitted with all plans submitted for City approval.

Checklist for Stormwater Standards
City of Lynchburg

OFFICE USE ONLY:
City Project Number:_____
Number of Plan Sets Received:_____
Date of Submittal:_____
Reviewer's Name:_____

Please provide complete documentation and details where applicable. NO PLAN SUBMITTAL will be complete unless all information is filled out completely. Indicate ***"Not Applicable"*** where appropriate.

Name of Development:_____

Owner Information:
Name: _____
Address:_____
_____
Phone Number:_____Fax Number: _____
e-mail address:_____

Developer Information:
Name: _____
Address:_____
_____
Phone Number:_____Fax Number: _____
e-mail address:_____

Designer Information:
Name of Company:_____
Address:_____
_____
Project Designer:_____Registration Number:_____
Phone Number:_____Fax Number: _____
e-mail Address:_____

Plan Requirements (Indicate *"N/A"* where appropriate)**:**

Yes	No	N/A	Sheet No.	Description	Remarks
□	□	□	_____	Development Name	_____
□	□	□	_____	Owner	_____
□	□	□	_____	Design Firm	_____
□	□	□	_____	Sealed, Signed and Dated	_____
□	□	□	_____	Sheet Number	_____
□	□	□	_____	Date	_____
□	□	□	_____	Revision Numbers and Dates	_____
□	□	□	_____	Designer's Certification	_____
□	□	□	_____	Owner's/Developer's Certification	_____
□	□	□	_____	North Arrow	_____
□	□	□	_____	Property Lines	_____
□	□	□	_____	Legend	_____
□	□	□	_____	Vicinity Map	_____
□	□	□	_____	Scale (min. at 1"=50')	_____
□	□	□	_____	General Description of Project	_____
□	□	□	_____	General Description of Erosion Controls	_____
□	□	□	_____	General Description of Stormwater Management Facilities	_____
□	□	□	_____	Project Schedule, Narrative, Sequence of Construction	_____
□	□	□	_____	Adjacent Property Owners	_____
□	□	□	_____	Existing Streets, Buildings, etc.	_____
□	□	□	_____	Wooded Limits	_____
□	□	□	_____	Wetland Limits	_____
□	□	□	_____	Easements	_____
□	□	□	_____	Land Use of Surrounding Areas	_____
□	□	□	_____	Original Contours (2-foot intervals)	_____
□	□	□	_____	Actual Field Survey	_____
□	□	□	_____	City/USGS Topographical Data	_____
□	□	□	_____	Existing Streams, Lakes, etc.	_____
□	□	□	_____	Proposed Contours (2-foot intervals)	_____
□	□	□	_____	Size and Location of Existing Culverts	_____
□	□	□	_____	Size and Location of Proposed Culverts	_____
□	□	□	_____	Limits of Drainage Area	_____
□	□	□	_____	Limits of Construction, Clearing & Grading	_____
□	□	□	_____	Existing & Proposed Improvements (including utilities and protective measures)	_____
□	□	□	_____	Delineation of FEMA 100-yr Floodplain	_____
□	□	□	_____	Location of Stormwater Management Facilities (includes details, plan, profile, and cross sections)	_____
□	□	□	_____	Maintenance plan for stormwater management facilities	_____
□	□	□	_____	Submitting 7 Set of Plans	_____

Calculation Requirements:

Yes	No	N/A	Sheet No.	Description	Remarks
□	□	□	_____	Development Name	_____
□	□	□	_____	Owner	_____
□	□	□	_____	Design Firm	_____
□	□	□		Sealed, Signed and Dated	_____
□	□	□	_____	Soils/Geotechnical Report/Analysis (for infiltration facilities)	_____
□	□	□	_____	Submitting 7 Sets of Calculations (including Pre & Post Runoff Calculations for 2-yr. & 10-yr. 24-hour storm events)	_____
				Piped Systems	
□	□	□	_____	Designed for 10-yr Storm	_____
□	□	□	_____	Analyzed for 25-yr Storm and 100-yr storm where adjacent to buildings	_____
□	□	□	_____	Minimum Velocity = 2.5 FPS	_____
□	□	□	_____	Headwall or Flared End Sections	_____
□	□	□	_____	Energy Dissipater Calculations	_____
□	□	□	_____	Gutter spread limited to ½ travel way or 8 to 10 feet from the face of the curb, whichever is less for a rainfall intensity of 3.5 inches per hour	_____
□	□	□	_____	Evaluation of Downstream System (Shall meet MS-19. See www.state.va.us/~DCR for technical bulletin on downstream analysis.)	_____
				Open Channel Systems	
□	□	□	_____	Capacity Designed for 10-yr Storm	_____
□	□	□	_____	Capacity Analyzed for 25-yr Storm and 100-yr storm where adjacent to buildings	_____
□	□	□	_____	Lining Designed for 2-yr Storm	
□	□	□	_____	Side Slopes 3 to 1 or flatter	_____
□	□	□	_____	Minimum Bottom Width = 3 Feet	_____
□	□	□	_____	Velocity Check (Liners provided, if needed)	_____
□	□	□	_____	Evaluation of Downstream System (Shall meet MS-19. See www.state.va.us/~DCR for technical bulletin on downstream analysis.)	_____
				Other Plan Submittals	
□	□	□	_____	DCR	_____
□	□	□	_____	VDOT	_____
□	□	□	_____	US Army Corps of Engineers	_____
□	□	□		VMRC	_____

***** Contact City Engineer for requirements if other than Residential Streets.

Submittal Worksheet for Dry Detention and Wet Retention Facilities:

The City of Lynchburg will follow the City Code and the Department of Conservation and Resources (DCR) Virginia Stormwater Management Handbook for all detention and retention basins within the City's jurisdiction. Please provide complete documentation and details where applicable. A complete stormwater management plan submittal includes a detention/retention basin worksheet for each basin, design calculations, evaluation of downstream system (shall meet MS-19), plan and specifications showing all basin and outlet structure details, and a fully executed operation and maintenance agreement. An incomplete submittal package will result in a request for additional information and will substantially delay final review and approval of the project. Indicate "Not Applicable" where appropriate if design is a dry detention basin.

I. Project Information (please complete the following information):

Project Name: _____

For projects with multiple basins, specify which basin this worksheet applies to: _____

Basin Bottom Elevation	_____	ft.	(average elevation of the floor of the basin)
Permanent Pool Elevation	_____	ft.	(elevation of the orifice invert out)
Temporary Pool Elevation	_____	ft.	(elevation of the outlet structure invert in)
Permanent Pool Surface Area	_____	sq. ft.	(water surface area at permanent pool elevation)
Drainage Area	_____	ac.	(on-site and off-site drainage to the basin)
Impervious Area	_____	ac.	(on-site and off-site drainage to the basin)
Permanent Pool Volume	_____	cu. ft.	(combined volume of main basin and forebay)
Temporary Pool Volume	_____	cu. ft.	(volume detained on top of the permanent pool)
Forebay Volume	_____	cu. ft.	
SA/DA used	_____		(surface area to drainage area ratio)
Diameter of Orifice and Number	____/____	in.	(draw down orifice diameter and number of)

II. Required Items Checklist

The following checklist outlines design requirements per the Virginia Stormwater Management Handbook (Department of Conservation and Resources, First Edition, 1999). Initial in the space provided to indicate the following design requirements have been met and supporting documentation is attached. *If a requirement has not been met, attach an explanation of why.*

Applicants Initials	
_____	Geotechnical study performed for Soils, Rock and Karst locations.
_____	The basin designed using 2-yr Storm for Channel Adequacy and 10-yr Storm for Flood Control.
_____	The temporary pool controls runoff from the 1 inch storm event.
_____	The basin length to width ratio is greater than 2:1.
_____	The basin side slopes are no steeper than 3:1.
_____	A 20-foot vegetation buffer to the maximum surface water elevation is provided.
_____	An emergency basin drain with gate valve is provided to drain the basin.
_____	The permanent pool depth, volume, and geometry is designed per DCR regulations.
_____	The temporary pool draws down in a minimum of 24 hours.
_____	The forebay volume is approximately equal to a minimum of 10% of the total basin volume
_____	Sediment storage is provided in the permanent pool
_____	An Emergency Spillway is provided and designed per DCR regulations.
_____	A Principal Spillway is provided and designed per DCR regulations.
_____	Access is provided for maintenance
_____	A minimum 30-foot vegetated filter is provided at the outlet
_____	Design checked and Certified for structural integrity and floodplain impacts for the 100-yr Storm
_____	A site specific operation and maintenance (O&M) plan is provided
_____	A vegetation management/mowing schedule is provided in the O&M plan
_____	Semi-annual inspections are specified in the O&M plan
_____	The Operation & Maintenance checklist (appendix 3B) in the Virginia Stormwater Management Handbook is specified in the O&M plan to be performed after every storm event.
_____	A specific sediment clean-out benchmark is listed (elevation or depth) in the O&M plan
_____	A responsible party is designated in the O&M plan

2.2.2 ADDITIONAL REQUIREMENTS

Approval of Stormwater Management Plans and Calculations by the City of Lynchburg does not complete the City of Lynchburg review process. All other applicable City Departments, State, and Federal agencies must also approve the plan as warranted. It shall be the sole responsibility of the Owner/Developer/Designer to acquire all applicable approvals.

3.0 HYDROLOGIC ANALYSIS

The purpose of this section is to establish standard procedures and criteria for the performance of hydrologic analyses in the City of Lynchburg.

3.1 DETERMINATION OF RUNOFF

The determination of runoff may be the single most important factor in the planning, design, and construction of drainage facilities. If the estimate of storm runoff is incorrect, the constructed facilities may be undersized or oversized. An improperly designed drainage system may be uneconomical, cause flooding, interfere with traffic, and may be a general nuisance in the affected area. However, determination of runoff can only be approximated using sound engineering processes to represent physical and climatic factors to best model the system.

There are many methods currently available to estimate peak flow rates. See the Department of Conservation and Recreation's (DRC) Virginia Stormwater Management Handbook, Volume 2, Chapter 4.

3.2 HYDROLOGICAL ANALYSIS OF WATERSHEDS SMALLER THAN 200 ACRES

For small drainage areas (less than 200 acres in size), the widely used Rational Method provides a useful means of determining peak discharges. In situations requiring determination of a complete flood hydrograph, and not just a peak discharge, a different method should be utilized. Engineers wishing to use an alternative design technique should consult the City of Lynchburg City Engineer prior to design.

3.2.1 Rational Method

The Rational Method represents an accepted method for determining peak storm runoff rates for small watersheds that have a drainage system unaffected by complex hydrologic situations such as ponding areas and storage basins. It is generally recommended that in the City of Lynchburg the Rational Method be used for areas of less than 200 acres. See the DCR's Virginia Stormwater Management Handbook, Volume 2 for methodology.

3.2.2 Hydrograph Development for Small Watersheds

Whenever the situation requires the determination of a complete flood hydrograph, and not just a peak discharge, Malcom's Method, as described in SECTION 3.3, may be used as well as SCS (TR-55) method.

3.3 HYDROLOGICAL ANALYSIS OF WATERSHEDS FROM 200 TO 640 ACRES

Hydrological analyses involving watersheds of greater than or equal to 200 acres and less than 640 acres may be completed using the Malcom Method to develop runoff hydrographs.

Malcom's Method for hydrograph development is useful in the design of facilities, which require an analysis over time. This procedure can be used in conjunction with the Soil Conservation Service (SCS) Method or the Rational Method as specified in the DCR's Virginia Stormwater Management Handbook, Volume 2. This methodology utilizes a pattern hydrograph to obtain a curvilinear design hydrograph which peaks at the design flow rate and which contains a runoff volume consistent with the design rainfall. The pattern hydrograph is a step function approximation to the dimensionless hydrograph proposed by the Bureau of Reclamation and the Soil Conservation Service [SCS, 1972].

This method is commonly used in designs that require storage areas, detention/retention basin design, ponding areas, or simply when a system needs to be routed in order to determine a peak elevation for any given storm event.

3.4 HYDROLOGIC ANALYSIS OF WATERSHEDS LARGER THAN 640 ACRES

See the DCR's Virginia Stormwater Management Handbook, Volume 2 or VDOT's Drainage Manual, chapter 6 for methodology.

Design storm rainfall can be described in terms of area of study, frequency, duration and distribution of intensity with time. The engineer's choice of storm frequency and duration is dependent upon the physical characteristics and location of the watershed, as well as the study objectives. A variety of hydrologic methodologies are presented in DCR's Virginia Stormwater Management Handbook and VDOT's Drainage Manual. The hydrologic method used should be selected from one of these publications with appropriate consideration of the strengths and limitations of the various alternative methodologies."

4.0 OPEN CHANNEL DESIGN

The purpose of this section is to establish standard procedures and criteria for Open Channel Design for the City of Lynchburg.

4.1 INTRODUCTION

Open channels, where allowed, shall be designed for the peak runoff produced by a 10-year frequency storm. Where applicable, as determined by the Plan Approving Authority, an analysis shall also be provided for the 25-year frequency storm, i.e. roadway overtopping, and for the 100-year frequency storm, i.e. adjacent building structures. The designer's calculations shall include the runoff from the property being developed and the runoff from contributing off-site areas, assuming ultimate development in accordance with the current zoning regulations and the **Comprehensive Land Use Plan**.

4.2 OPEN CHANNEL DESIGN

The proper hydraulic design of a channel is of primary importance in insuring that flooding, sedimentation and erosion problems do not occur. The following general criteria should be used in the design of open channels:

4.2.1 Design Frequencies for Open Channel Design

All open channels in the City of Lynchburg shall be designed to contain the runoff from 10-year frequency storm, which includes the design to have sufficient freeboard to provide for adequate drainage of lateral storm sewers. The drainage system shall be adequate and properties over which the surface waters are conveyed, from the development site to discharge point, shall not be adversely affected.

In those cases where channel modifications are necessary to control increased flow from proposed development, proposed water surface profiles are restricted such that the 100-year flood profile under existing conditions shall not be increased. If the capacity of the existing channel downstream of the project is less than the 100-year design discharge, consideration shall be given for more frequent events to ensure that the severity and frequency of down stream flooding are not increased.

4.2.2 Required Documentation for Open Channel Designs

The following information must be submitted to the City of Lynchburg for the design of open channels, but is not limited the following:

1) **Vicinity Map:** A vicinity map of the site and subject reach.

2) **Site Map:** A detailed map of the area and subject reach.

3) **Watershed Map:** A watershed map showing existing and proposed drainage area boundaries along with all sub-area delineations and all areas of existing or proposed development.

4) **Discharge Calculations:** Discharge calculations specifying the methodology and key assumptions used, along with computed discharges at key locations. The designer's calculations shall include the runoff from the property being developed and the runoff from contributing off site areas, assuming ultimate development in accordance with the current zoning regulations and the **Comprehensive Land Use Plan**.

5) **Hydraulic Calculations:** Hydraulic calculations specifying the methodology used. All assumptions and values of design parameters must be clearly stated.

6) **Plotted Cross-Sections:** Typical existing and proposed cross-sections.

4.2.3 Channel Flow Velocities

Excessive flow velocities in open channels can cause erosion and destabilize side slopes, and may pose a threat to safety. Velocities, which are too low, may allow the deposition of sediment and subsequent channel clogging. Table 4.01 provides desirable average and maximum allowable velocities based on 10-year flow rates.

Table 4.01 Allowable Flow Velocities for Channel Design

Channel Description	Average Velocity (Feet Per Second)	Maximum Velocity (Feet Per Second)
Grass Lined: Predominantly Clay Soils	3.0	5.0
Grass Lined: Predominantly Sand Soils	2.0	4.0
Rip-Rap Lined	5.0	8.0
Concrete Lined	6.0	10.0

4.2.4 Channel Flow-Line Slope

Slope of the channel flow-line (invert) is generally governed by topography and the energy head required for flow. Since flow-line slope directly affects channel velocities, channels should have sufficient grade to prevent significant siltation. However, slopes should not be so large as to create erosion problems. In the City of Lynchburg, the minimum recommended longitudinal slope shall be 0.5 percent (0.005). The use of flatter slopes must be approved by the City Engineer. The maximum channel invert slope will be limited by the maximum flow velocities given in Table 4.01. Appropriate channel drop structures may be used to limit channel invert slopes in steep areas.

4.2.5 Channel Side Slope

In grass-lined channels, the normal maximum side slope will be 3 horizontal to 1 vertical (3:1), which is the practical limit for mowing equipment. In some areas, local soil conditions may dictate the use of side slopes flatter than 3:1 to ensure slope stability.

4.2.6 Channel Bottom Width

In grass-lined channels, the minimum channel bottom width shall be three (3) feet. In concrete-lined channels, the minimum bottom width shall be two (2) feet.

4.3 CHANNEL EROSION CONTROL

Erosion protection is necessary to insure that channels maintain their capacity and stability and to avoid excessive transport and deposition of eroded material.

All erosion and sediment control measures shall be designed in accordance with the DCR's Virginia Erosion and Sediment Control Law. The Designer is to reference the *Virginia Erosion and Sediment Control Handbook,* [Third Edition, 1992]. This manual contains valuable information and tools for developing plans to minimize soil erosion and prevent sedimentation pollution associated with land-disturbing activities.

5.0 CULVERT DESIGN

The purpose of this section is to establish standard procedures and criteria for Culvert Design for the City of Lynchburg.

5.1 INTRODUCTION

Private drainage culverts and public drainage culverts within a subdivision or site development sub-basin shall be designed for the peak runoff produced by a 10-year storm and analyzed for the 25-year storm event.

Curb inlets shall be designed for a gutter spread limited to ½ the travel way or 8 to 10 feet from the face of the curb, whichever is less for a rainfall intensity of 3.5 inches per hour.

The designer's calculations shall include the runoff from the property being developed and the runoff from contributing off-site areas, assuming ultimate development in accordance with the current zoning regulations and the **Comprehensive Land Use Plan**.

5.2 CURB INLET DESIGN

The curb inlet design procedure shall be as written in the VDOT Drainage Manual, latest revision.

5.3 PIPE CULVERT DESIGN - GENERAL

Pipe culverts shall be aligned parallel to the longitudinal axis of the channel, as much as possible, to insure maximum hydraulic efficiency and to minimize erosion. In areas where a change in alignment is necessary, the change shall be accomplished upstream of the culvert in the open channel. Appropriate erosion protection shall be provided.

Pipe culverts crossing beneath the roadway shall be designed to span from ditch line to ditch line.

All pipe culverts are required to have Flared End Sections or Headwall/Endwalls.

The minimum pipe culvert diameter shall be 15 inches to minimize clogging and maintenance for all pipe culverts within City of Lynchburg rights-of-ways and easements.

5.4 HYDRAULIC DESIGN OF CULVERTS

The City of Lynchburg uses the design procedures of FHWA *HEC-5* for the design of pipe culverts. *HEC-5* was designed to analyze flow in pipes using many different variables.

5.5 EROSION CONTROL

Inlet and/or outlet protection is necessary to insure those channels upstream and downstream of pipe culverts maintain stability and to avoid excessive transport and deposition of eroded material.

All erosion and sediment control measures shall be designed in accordance with the DCR's Virginia Erosion and Sediment Control Law. The Designer is to reference the *Virginia Erosion and Sediment Control Handbook,* [Third Edition, 1992]. This manual contains valuable information and tools for developing plans to minimize soil erosion and prevent sedimentation pollution associated with land-disturbing activities.

6.0 DETENTION/RETENTION DESIGN

Refer to DCR's Virginia Stormwater Management Handbook and Chapter 16, Section 16.2 of the City Code.

7.0 RESPONSIBILITY

7.1 LIMITS OF PUBLIC OWNERSHIP AND MAINTENANCE RESPONSIBILITY:

The following components of the drainage infrastructure will **not** be maintained by the City of Lynchburg:

A. **The City of Lynchburg assumes no liability or responsibility for adjudicating disputes between property owners regarding non-publicly generated storm water.**

B. Drainage systems on private property that do not have dedicated easements.

C. Drainage systems maintained by VDOT as part of its State highway system.

D. **Detention/Retention/Water Quality Pond Areas**: The City will not accept these areas for maintenance; however, the City reserves the right to enter these areas and remove any debris a blockage that is adversely affecting the City's drainage system. This will be done in an emergency situation without notice. Under normal conditions, the City will contact the owner/developer to have said blockages removed. If unable to do so within a reasonable time, the City reserves the right to charge the owner/developer for any expense incurred by the City in doing so. For additional regulations/requirements regarding detention/retention ponds, see Section 16.2 of the City Code.

7.2 NATURAL WATER COURSES

Natural ditches, streams, creeks and rivers shall not be maintained by the City except to remove debris/blockages that are adversely affecting the City's drainage system.

7.3 LIMITATION OF CONSEQUENTIAL DAMAGE TO PRIVATE FACILITIES LOCATED ON PUBLIC EASEMENTS

All public easements including storm sewer is to remain clear of obstructions. No buildings, fences, trees, shrubs or other obstructions shall be placed in any easement. Driveways, walkways, asphalt and parking lots may be permitted in easements; however, the City reserves the right to remove such asphalt, concrete, base course and sod as necessary to access its facility in the case of emergency. Pavement or concrete will be replaced with a patch. Sod will be replaced with Fescue or rye seeding. The City will not be responsible for replacing a property owners sod after repairing a drainage line.

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Directory: J:\DESIGN\standard details10.21.2004\STANDARD DETAILS10.21.2004\Sopecifications10-27-04
Template: C:\Documents and Settings\shradis\Application Data\Microsoft\Templates\NORMAL.DOT
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Author: MIKE STOCKS
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